stationary interfering signals; and

means for subtracting said estimated value from said received acoustic signal to produce a representation of a wanted speech magnitude spectrum.

33. Apparatus according to claim 32, wherein said means for generating estimated value includes processing means configured to estimate a transfer function for an acoustic channel between each source of said non-stationary interfering signals and said means for receiving an acoustic signal.

34. Apparatus according to claim 33, wherein said processing means is configured to estimate transfer functions for said non-stationary interfering signals produced by left and right stereo channel transmissions.

35. Apparatus according to Claim 34, wherein said estimation of said transfer functions is achieved by said processing means executing an iterative algorithm on a frame-by-frame basis, the frames being constituted by said acoustic signals received during successive time periods.

36. Apparatus according to Claim 35, wherein said processing means is configured to estimate respective magnitudes of said left and right channel interference signals,

said magnitude of left channel interference signal is estimated by subtracting said right channel interference signal magnitude estimated during previous said iteration from said acoustic signal received at current said iteration; and

said magnitude of right channel interference signal is estimated by subtracting said

left channel interference signal magnitude estimated during previous said iteration from said acoustic signal received at current said iteration.

37. Apparatus according to Claim 36, wherein said transfer function estimate for said right stereo acoustic channel is determined by dividing said right channel interference magnitude estimate by said interfering signal transmitted from said right acoustic stereo channel; and

said transfer function estimate for said left stereo acoustic channel is determined by dividing said left channel interference magnitude estimate by said interfering signal transmitted from said left acoustic stereo channel.

38. Apparatus according to Claim 37, wherein said right acoustic channel transfer function estimation is performed for a said iteration only if a ratio of total energy of said right acoustic stereo channel interfering signal over total energy of said left acoustic stereo channel interfering signal exceeds a predetermined threshold value; and

said left acoustic channel transfer function estimation is performed for a said iteration only if a ratio of total energy of said left acoustic stereo channel interfering signal over total energy of said right acoustic stereo channel interfering signal exceeds a predetermined threshold value.

39. Apparatus according to Claim 38, wherein said ratio and threshold comparisons are applied to individual frequency components in spectra of said signals.

40. Apparatus according to Claim 39, wherein said left and right stereo acoustic

channel transfer functions are multiplied by $(1-|\eta(k)|)$ where $\eta(k)$ is coherence of said left and right interfering signals at a frequency index k.

41. Apparatus according to Claim 35, wherein said transfer function estimate for said right stereo acoustic channel is obtained using an expression:

$$\hat{H}_{AR}(k) = \frac{Y(k)}{R''(k)} = \frac{H_{AR}(k).R''(k)}{R''(k)} = H_{AR}(k)$$

and said transfer functions estimate for said left stereo acoustic channel is obtained using an expression:

$$\hat{H}_{AL}(k) = \frac{Y(k)}{L''(k)} = \frac{H_{AL}(k).L''(k)}{L''(k)} = H_{AL}(k)$$

wherein $R''(k)=H_{CR}(k).C(k)$, with $C(k)$ being a common component of said left and right stereo channel signals and $H_{CR}(k)$ is a transfer function between common said left and right stereo channel transmissions, and said right stereo channel and $L''(k)=L(k)-H_{CL}(k).C(k)$, where $H_{CL}(k)$ is a transfer function between common said left and right stereo channel transmissions and said left stereo channel signal.

42. Apparatus according to claim 33, wherein said processing means further comprises means for smoothing said estimated transfer functions in time domain.

43. Apparatus according to claim 42, wherein said means for smoothing in time domain comprises a first order recursive filter.

44. Apparatus according to claim 33, wherein said processing means further comprises means for smoothing said estimated transfer functions in frequency domain.

45. Apparatus according to Claim 44, wherein said means for smoothing in frequency domain comprises a Finite Impulse Response filter.

46. Apparatus according to claim 33, wherein said processing means includes means for performing a Fourier Transform.

47. Apparatus according to claim 32, wherein said non-stationary interfering signals are produced by an electronic acoustic device operating in a vehicle.

48. Apparatus according to claim 32, wherein said means for receiving an acoustic signal comprises a microphone.

49. A method of cancellation of one or more non-stationary interfering signals for speech recognition, said method comprising steps of:

receiving an acoustic signal;

generating an estimated value for a magnitude spectrum of said non-stationary interfering signal; and

subtracting said estimated value from said received acoustic signal to produce a representation of a wanted speech magnitude spectrum.

50. Method according to Claim 49, wherein said step of generating an estimated value comprises estimating a transfer function for an acoustic channel between each source of said non-stationary interfering signals and said means for receiving an acoustic signal.

51. Method according to Claim 50, wherein said transfer functions are estimated for non-stationary interfering signals produced by left and right stereo channel transmissions.

52. Method according to Claim 51, wherein said steps are executed iteratively on a frame-by-frame basis, the frames being constituted by said acoustic signals received during successive time periods.

53. Method according to Claim 52, wherein said step of estimating a transfer function includes:

estimating a magnitude of said left channel interference signal by subtracting said right channel interference signal magnitude estimated during previous said iteration from said acoustic signal received at current said iteration; and

estimating magnitude of said right channel interference signal by subtracting said left channel interference signal magnitude estimated during previous said iteration from said acoustic signal received at current said iteration.

54. Method according to Claim 53, further comprising steps of:

dividing said right channel interference magnitude estimate by said interfering signal transmitted from said right acoustic stereo channel; and

dividing said left channel interference magnitude estimated by said interfering signal transmitted from said left acoustic stereo channel.

55. Method according to Claim 54, wherein said step of estimating right acoustic channel transfer function is performed for a said iteration only if a ratio of total energy of

said right acoustic stereo channel interfering signal over total energy of said left acoustic stereo channel interfering signal exceeds a predetermined threshold value; and

said step of estimating left acoustic channel transfer function estimate is performed for a said iteration only if a ratio of total energy of said left acoustic stereo channel interfering signal over total energy of said right acoustic stereo channel interfering signal exceeds a predetermined threshold value.

56. Method according to Claim 55, wherein said ratio and threshold comparisons are applied to individual frequency components in spectra of said signals.

57. Method according to Claim 56, wherein said left and right stereo acoustic channel transfer functions are multiplied by $(1-|\eta(k)|)$ where $\eta(k)$ is coherence of said left and right interfering signals at a frequency index k.

58. Method according to Claim 52, wherein said transfer function estimate for said right stereo acoustic channel is obtained using an expression:

$$\hat{H}_{AR}(k) = \frac{Y(k)}{R^{H}(k)} - \frac{H_{AR}(k)\, R^{H}(k)}{R^{H}(k)} - H_{AR}(k)$$

and said transfer functions estimate for said left stereo acoustic channel is obtained using an expression:

$$\hat{H}_{AL}(k) = \frac{Y(k)}{L^{H}(k)} - \frac{H_{AL}(k).L^{H}(k)}{L^{H}(k)} - H_{AL}(k)$$

wherein $R''(k)=H_{CR}(k).C(k)$, with $C(k)$ being a common component of said left and right stereo channel signals and $H_{CR}(k)$ is a transfer function between common said left and right stereo channel transmissions, and said right stereo channel

and $L''(k)=L(k)-H_{CL}(k).C(k)$, where $H_{CL}(k)$ is a transfer function between common said left and right stereo channel transmissions and said left stereo channel signal.

59. Method according to Claim 49, further comprising a step of smoothing said estimated transfer functions in time domain.

60. Method according to Claim 49, further comprising a step of smoothing said estimated transfer functions in frequency domain.

61. A speech recognition system including apparatus according to claim 32.

62. An electronic acoustic device including apparatus according to claim 32.

63. Apparatus for cancellation of one or more non-stationary interfering signals for speech recognition, said apparatus comprising:

a receiver for receiving an acoustic signal;

an estimator for generating an estimated value of a magnitude spectrum of said non-stationary interfering signals; and

a subtractor component for subtracting said estimated value from said received acoustic signal to produce a representation of a wanted speech magnitude spectrum.

64. Apparatus according to claim 63, wherein said estimator includes a processor configured to estimate a transfer function for an acoustic channel between each source of

said non-stationary interfering signals and the receiver.

65. Apparatus according to claim 64, wherein said processor is configured to estimate transfer functions for said non-stationary interfering signals produced by left and right stereo channel transmissions.

In the Abstract:

Please replace the text of the Abstract on page 37 with the following replacement text:

System for cancellation of non-stationary interfering signals, particularly for use for mitigating effects of such interferers produced by in-car entertainment (ECAD) devices for speech recognition applications. The system spectrally analyses signals output by the ECAD before and after they are passed through an in-car acoustic channel. A model of the acoustic channel is built by the system's algorithm. For speech recognition the model is spectrally subtracted from a signal received at a microphone in order to recover a wanted speech signal. The acoustic channel model is built by estimating frequency domain acoustic transfer functions between each loudspeaker used by the ECAD and the microphone.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Abstract:

Please replace the text of the Abstract on page 37 with the following replacement text:

[Cancellation of non-stationary interferer signals

for speech recognition]

System for cancellation of non-stationary interfering signals, particularly for use for mitigating effects of such interferers produced by in-car entertainment (ECAD) devices for speech recognition applications. The system spectrally analyses signals output by the ECAD before and after they are passed through an in-car acoustic channel. A model of the acoustic channel is built by the system's algorithm. For speech recognition the model is spectrally subtracted from a signal received at a microphone in order to recover a wanted speech signal. The acoustic channel model is built by estimating frequency domain acoustic transfer functions between each loudspeaker used by the ECAD and the microphone.

[Figure 1.]